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AUTHOR(S):

Huys, Rony; Ohtsuka, Susumu; Boxshall, Geoffrey
A.; Ito, Tatsunori

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***Itoitantulus misophricola* gen. et sp. nov.: First Record of
Tantulocarida (Crustacea: Maxillopoda)
in the North Pacific Region**

RONY HUYS¹, SUSUMU OHTSUKA², GEOFFREY A. BOXSHALL¹
and TATSUNORI ITÔ³

¹*Department of Zoology, The Natural History Museum, Cromwell Road, London.
SW7 5BD, England,* ²*Fisheries Laboratory, Hiroshima University, Takehara,
Hiroshima 725, Japan, and* ³*The Seto Marine Biological Laboratory,
Kyoto University, Wakayama 649-22, Japan*

ABSTRACT—A new tantulocaridan, *Itoitantulus misophricola* Huys, Ohtsuka et Boxshall gen. et sp. nov., (Crustacea) ectoparasitic on a hyperbenthic misophrioid copepod, *Misophriopsis okinawensis* Ohtsuka, Huys, Boxshall et Itô, 1992, is described from Kume Island, Okinawa, South Japan. This is the first record of Tantulocarida from the North Pacific region. The new tantulocaridan is placed in the Deoterthridae on account of the 1-segmented abdomen, the absence of a rostrum in the tantulus larva, the segmentation of the rami of the thoracopods, and the position of the expanded trunk sac in the male. The new genus can be distinguished from other deoterthrid genera by the absence of a lobate endite of thoracopod 1 and the presence of the dorsally directed, recurved spine on the apex of the sixth thoracopod in the tantulus larva.

INTRODUCTION

The Tantulocarida was established as a new class of the subphylum Crustacea by Boxshall and Lincoln [1]. The recent phylogenetic analysis by Boxshall and Huys [2] revealed that the Tantulocarida is a taxon within the class Maxillopoda and closely related to the Thecostraca, Branchiura and Ostracoda in having an unpaired penis derived from the seventh thoracic legs of the adult male. The maxillopodan affinities of the Tantulocarida were supported by Huys' [3] new interpretation of the trunk tagmosis of tantulocarids. All known species of the Tantulocarida are ectoparasitic on crustacean hosts, including harpacticoid copepods, myodocopid ostracods, asellote isopods, cumaceans, and tanaidaceans. More than 20 species have been described from the subtidal to the abyssal depth zones in the North and South Atlantic, the Indian and the South Pacific Oceans [1–

15]. The hypothetical life cycle of the Tantulocarida was presented by Boxshall and Lincoln [8] and Huys [3]. It is characterized by extreme abbreviation: tantulocaridans have a single larval stage which attaches to a crustacean host, the female then sloughs its pedigerous and abdominal somites and forms a sac-like trunk containing eggs behind the cephalic shield, whereas the male differentiates within the expanded larval thoracic somites and is released as a free-swimming stage with six pairs of powerful thoracic legs for swimming but no mouthparts.

A new species of the Tantulocarida infested a new species of the Misophrioida collected from the near-bottom off Kume Island, Okinawa, South Japan (see [16]). This is the first record of a tantulocaridan in the North Pacific Ocean and the first of a tantulocaridan parasitic on misophrioid copepods. The present paper describes immature females and males, and the tantulus larva of the new tantulocaridan from Okinawa.

One of the authors, Tatsunori Itô deceased suddenly on April 8, 1990 at the age of 45 before completion of this study. The first three authors

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² To whom all correspondence should be addressed.

³ Deceased on April 8th, 1990

(RH, SO, GAB), therefore, determined on carrying out his intention and dedicate this study to the late Dr. T. Itô.

MATERIALS AND METHODS

The host misophrioid copepod *Misophriopsis okinawensis* Ohtsuka, Huys, Boxshall et Itô, 1992 [16] was collected at a depth of about 167 m off Kume Island, Okinawa, South Japan (26°17.9'N, 126°54.2'E) on 23 May 1989 (local time: 0824–0858). The sampling gears and techniques and laboratory procedures were described in detail in Ohtsuka *et al.* [16]. All types of the new species of the Tantulocarida are deposited in the collections of The Natural History Museum, London.

Family Deoterthridae Boxshall et Lincoln

Genus *Itoitantulus* Huys, Ohtsuka et Boxshall gen. nov.

Diagnosis. Tantulus larva comprising cephalon, 6 pedigerous somites and 2-segmented urosome. First thoracic tergite largely concealed beneath posterior margin of dorsal cephalic shield. Cephalic shield tapering anteriorly, giving a pointed appearance; ornamentation consisting of 4 anterolateral, 2 dorsal and 6 posterior pairs of pores and 2 distinct longitudinal lamellae. Cephalic stylet straight. Thoracopods 2 to 5 with well developed endite, thoracopods 1 and 6 without endite. Protopods of thoracopods 1 to 5 undivided; exopods apparently 2-segmented with 2 (leg 1), 4 (legs 2–4) or 5 setae (leg 5). Setae of legs 2 to 5 on distal exopod segment, leg 1 with 1 seta on each segment. Endopod apparently 1-segmented, lacking setae in leg 1 or armed with 2 setae (legs 2–5). Thoracopod 6 without distinct rami, armed with 2 setae apically, the medial seta very strong and curved. Posterior urosomal somite ornamented with 5 incomplete transverse lamellae and an array of spinous processes around posterior margin. Caudal rami armed with 2 long, distinctly geniculate setae and a shorter simple seta. Trunk sac containing adult male formed posterior to 6th thoracic tergite. Male cephalothorax with 4 pairs of aesthetascs anteriorly. Penis slightly recurved. Caudal rami with 3 setae. Adult female with scar

formed after larval trunk sloughed located some distance posterior to ventral margin of head. Ectoparasitic on a misophrioid copepod *Misophriopsis okinawensis* Ohtsuka, Huys, Boxshall et Itô, 1992.

Type species. *Itoitantulus misophricola* Huys, Ohtsuka et Boxshall gen. et sp. nov.

Etymology. The generic name “*Itoitantulus*” is named in honor of the late Dr. Tatsunori Itô, and derived from his family name, Itô and the Latin tantulus, which forms part of the name Tantulocarida.

Itoitantulus misophricola Huys, Ohtsuka et Boxshall gen. et sp. nov.
(Figs. 1–7)

Types. All types infesting *Misophriopsis okinawensis* Ohtsuka, Huys, Boxshall et Itô, 1992 collected from the sandy bottom (ca. 167 m in depth) off Kume Island, Okinawa, South Japan, and deposited in the Natural History Museum, London. Holotype: tantulus larva attached on antennary basis of *M. okinawensis*. BM (NH) 1991. 183. Paratypes: 3 tantulus larvae, 2 early stage males, 4 early stage females, BM (NH) 1991. 184–192.

Description. *Tantulus larva* (holotype). Body comprising cephalon covered by dorsal shield, 6 pedigerous somites and 2-segmented urosome (Fig. 1-A, B). Total body length 156 µm, measured from tip of cephalon to posterior margin of caudal rami. Cephalon tapering markedly towards oral disc; posterior margin of dorsal shield slightly convex. Shield about 2.1 times longer than wide (78 µm × 37 µm); 1 pair of longitudinal epicuticular lamellae extending almost to base of oral disc; short transverse lamellae present near rear margin. Rostrum absent. Oral disc about 13 µm in diameter, located anteroventrally at frontal margin of head; disc bearing 1 pair of filament-like structures laterally, originating beneath the outer sheath. Pore pattern comprising 4 anterolateral pairs, 1 of which with sensillum, 2 dorsal pairs and 6 posterolateral pairs, 2 of which with sensillum. Ventral surface lacking ornamentation. Cephalic stylet visible through integument, about 36 µm long, more or less straight, without lateral barbs, base hollow. Little internal structure discernible.

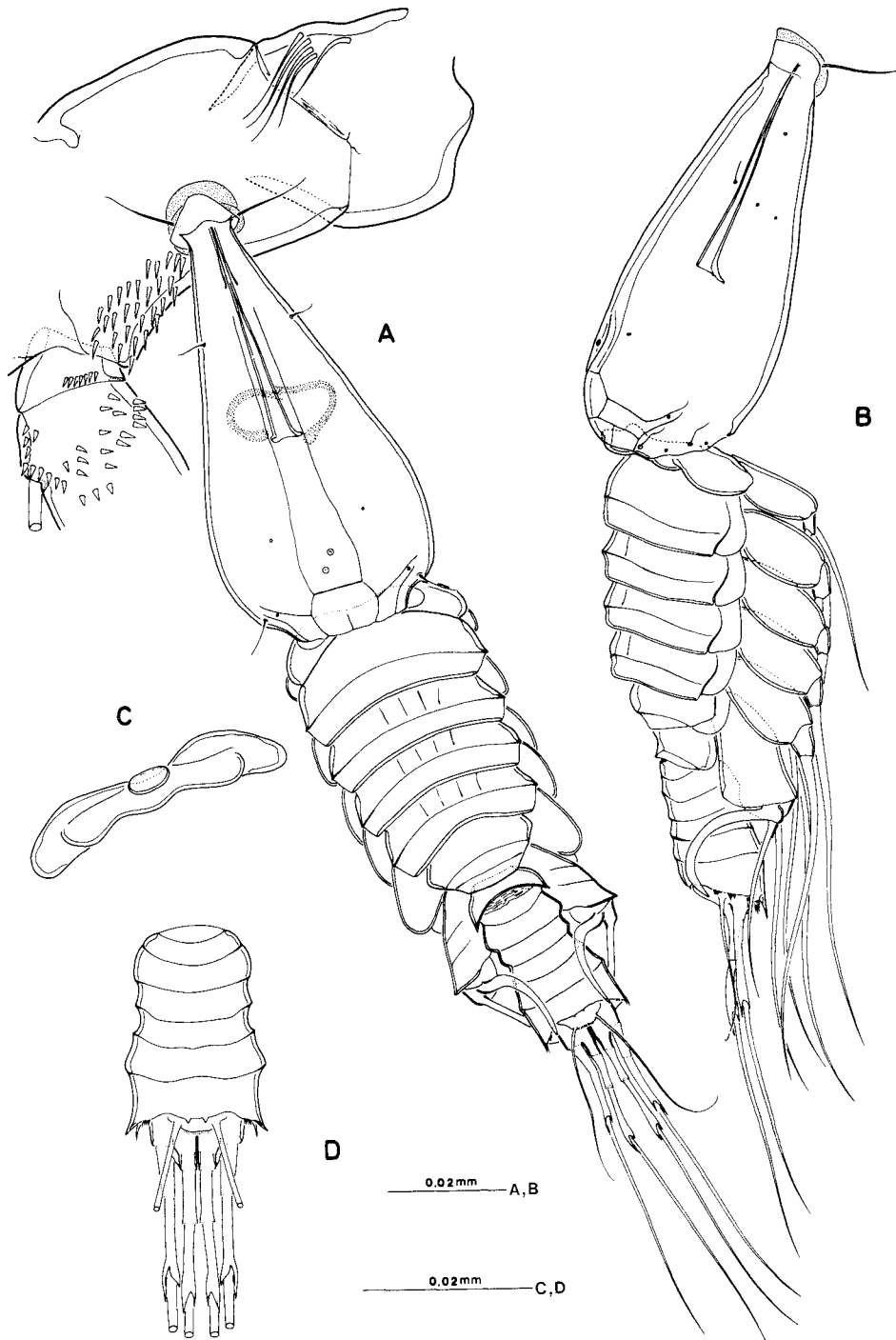


FIG. 1. *Itoitantulus misophricola* gen. et sp. nov. Tantulus larva (holotype). A. Habitus, dorsal view, tantulus larva attached to antennary basis of the host *Misophriopsis okinawensis*. B. Habitus, lateral view; C. Thoracic somite 1, anterior view; D. Abdomen, dorsal view.

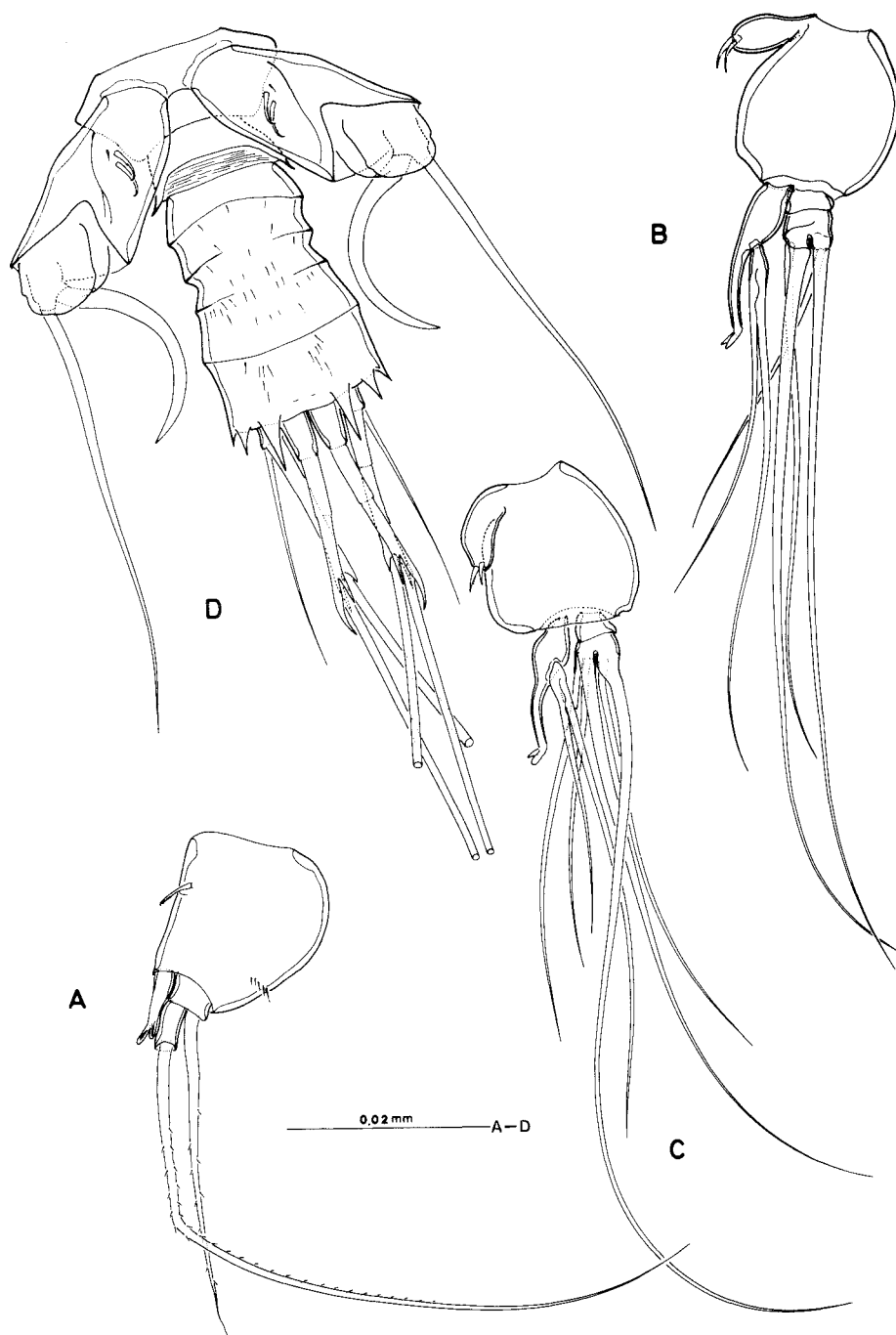


FIG. 2. *Itoitantulus misophricola* gen. et sp. nov. Tantulus larva (holotype). A. Thoracopod 1; B. Thoracopod 2; C. Thoracopod 5; D. Thoracopod 6, seventh thoracic somite and abdomen, ventral view.

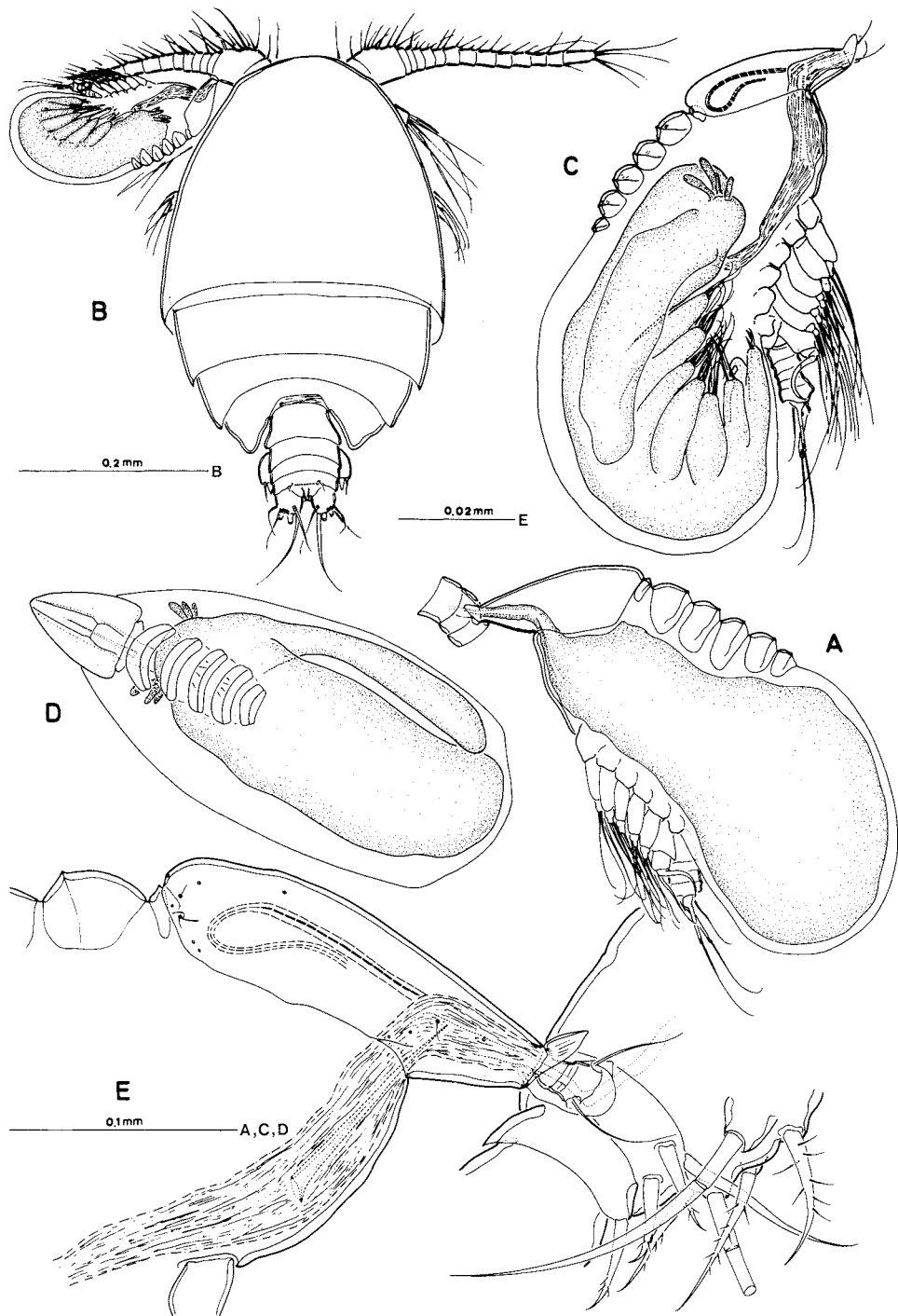


FIG. 3. *Itoitantulus misophricola* gen. et sp. nov. Male contained within trunk sac formed by the preceding tantulus stage (paratypes). A. Early stage male attached to second exopodal segment of antenna of *Misophriopsis okinawensis* (adult female); B. Early stage male attached to antennule of *M. okinawensis* (copepodid V female); C. Early stage male more developed than the stage illustrated in A, enlargement of B, lateral view; D. Same, dorsal view; E. Lateral view of head of early stage male attached to antennular segment of the host *M. okinawensis*, showing internal anatomy.

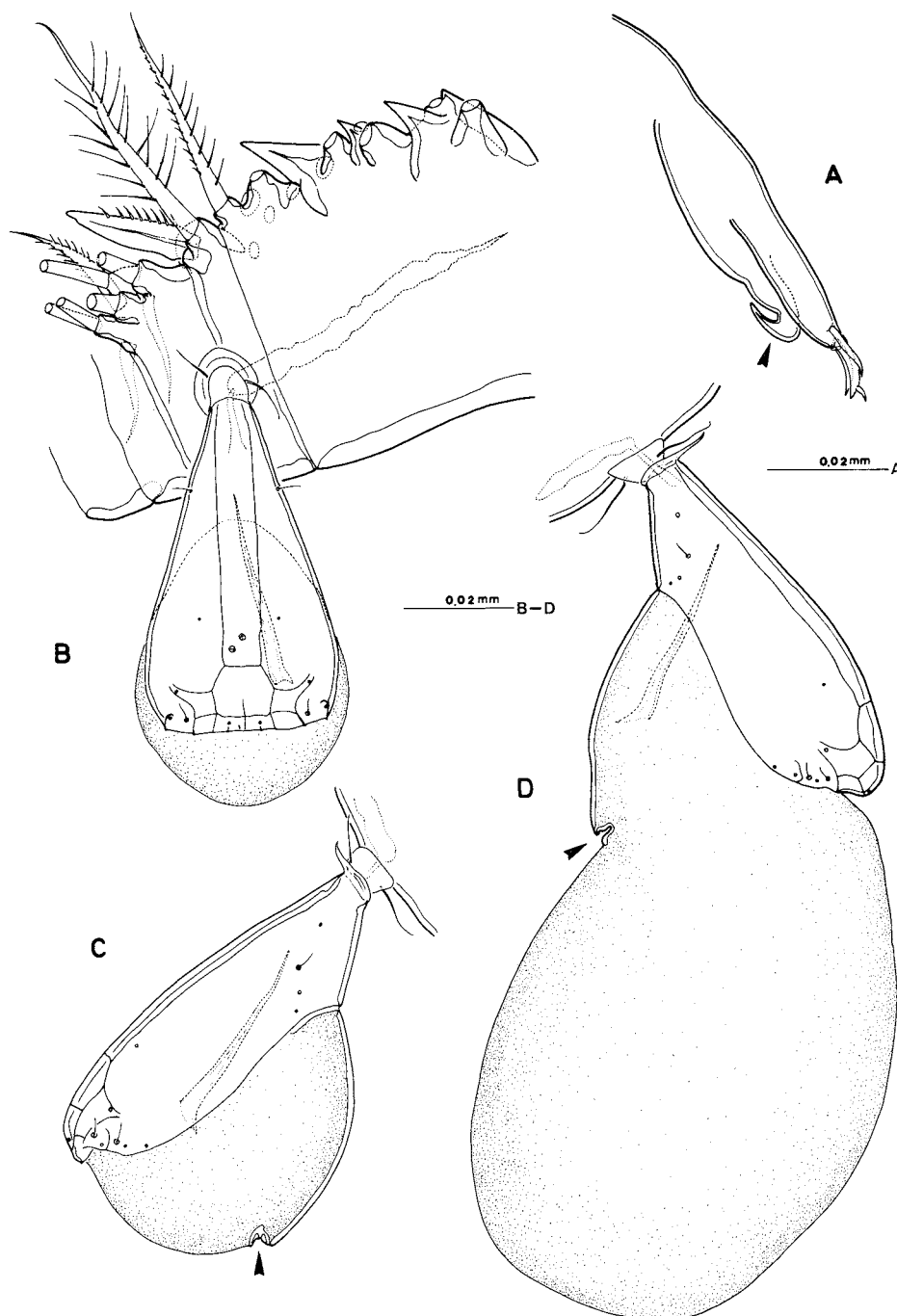


FIG. 4. *Itoitantulus misophricola* gen. et sp. nov. Early stage male (A) and female (B-D) (paratypes). A. Recurved penis (indicated by an arrowhead) and abdomen of early stage male (see Fig. 3-C), lateral view; B. Early stage female attached to antennular segment of *Misophriopsis okinawensis*, dorsal view; C. Early stage female, lateral view, scar indicated by an arrowhead; D. Early stage female more developed than the stage illustrated in C, lateral view, scar indicated by an arrowhead.

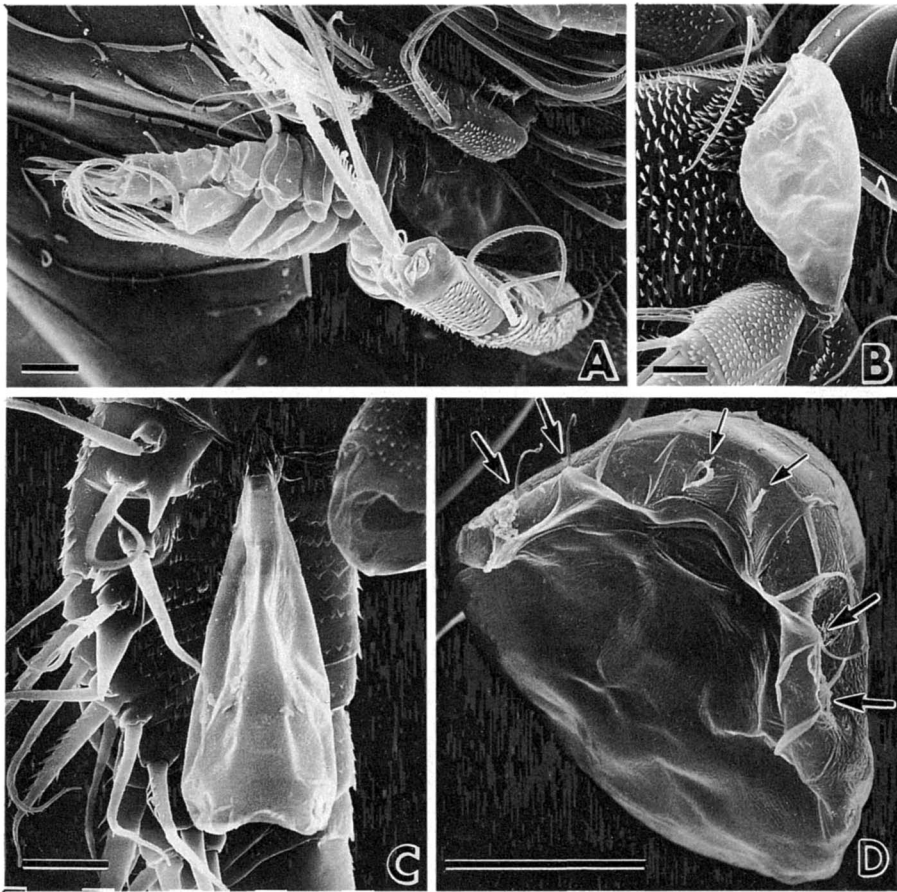


FIG. 5. *Itoitantulus misophricola* gen. et sp. nov. SEM micrographs of tantulus larva. A. Habitus, lateral view, attached to antenna of *Misophriopsis okinawensis*; B. Isolated head attached to antenna of host, dorsolateral view; C. Isolated head attached to antennule of host, dorsal view; D. Isolated head, posteroventral view, sensilla indicated by large arrows, pores with collar by small arrows. Scale bars = 10 μm .

Thoracic somites 1 to 6 each with well developed tergite, that of 1st somite (Fig. 1-C) small, largely concealed beneath posterior rim of cephalic shield; 3rd to 5th tergites ornamented with 4 longitudinal lamellae. Each somite with well developed thoracopod. Thoracopod 1 (Fig. 2-A) comprising undivided protopod, 2-segmented exopod and 1-segmented endopod; protopod without endite, armed with single medial spine; endopod with bifid tip; exopod with short lateral seta on 1st segment and long apical seta on 2nd segment. Thoracopods 2 to 4 (Fig. 2-B) comprising undivided protopod bearing endite armed with 2 coupling spines, 2-segmented exopod and 1-segmented endopod; exopod with 2 long and 2 medium length setae on

distal segment; endopod with bifid tip, armed with 2 setae arising from common base located laterally on proximal swollen part of ramus. Thoracopod 5 (Fig. 2-C) as in thoracopods 2 to 4 but with 2 long and 3 short setae on exopod. Sixth thoracopod (Fig. 2-D) with undivided protopod bearing 2 coupling spines medially; 2 apical setae representing rami, lateral seta slender and straight, powerful medial seta strongly recurved dorsally.

Urosome (Figs. 1-D, 2-D) 32 μm in length, comprising small 7th thoracic somite and large abdominal somite. Seventh thoracic somite unornamented. Abdominal somite 1.5 times longer than wide (25 $\mu\text{m} \times 16 \mu\text{m}$); ornamented with 5 transverse epicuticular lamellae, 2 of which are

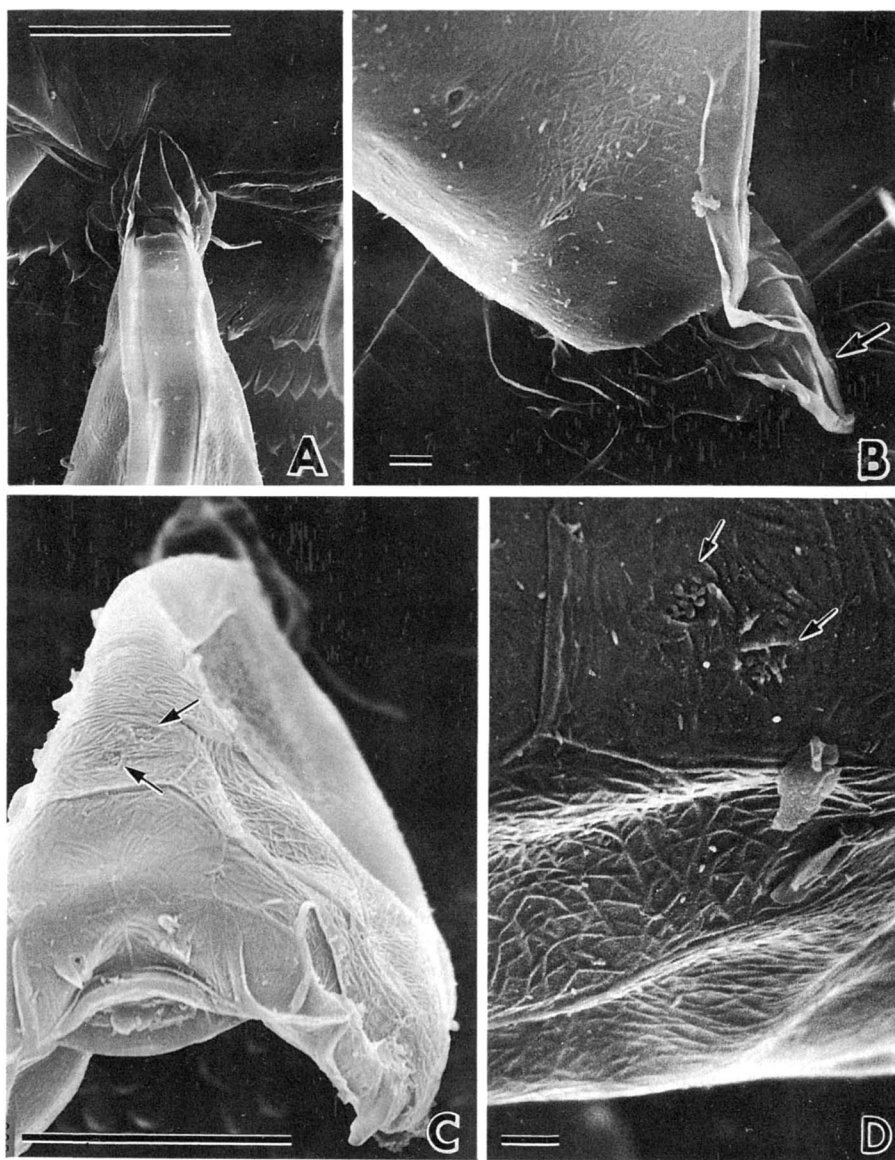


FIG. 6. *Itoitantulus misophricola* gen. et sp. nov. SEM micrographs of tantulus larva. A. Oral disc, dorsal view; B. Oral disc, dorsolateral view, folded anterior part of cephalic shield indicated by an arrow; C. Cephalic shield of isolated head, posterodorsal view, dorsal pores indicated by arrows; D. Dorsal pores indicated by arrows. Scale bars = 10 μm (A, C); 1 μm (B, D).

incomplete ventrally; posterior margin with 3 pairs of spinous processes ventrally, decreasing in size away from midline. Caudal rami not clearly delimited from somite; bearing 2 pairs of large setae, each with transverse flexure plane proximally and a complex, sheathed geniculation more distally;

3rd pair of simple setae present, arising dorsal to main caudal setae, either side of operculum-like structure with finely spinulated free margin.

Male metamorphosis (paratypes). Adult male formed in reflexed position within expanded trunk sac of preceding tantulus larva (Fig. 3-A~D).

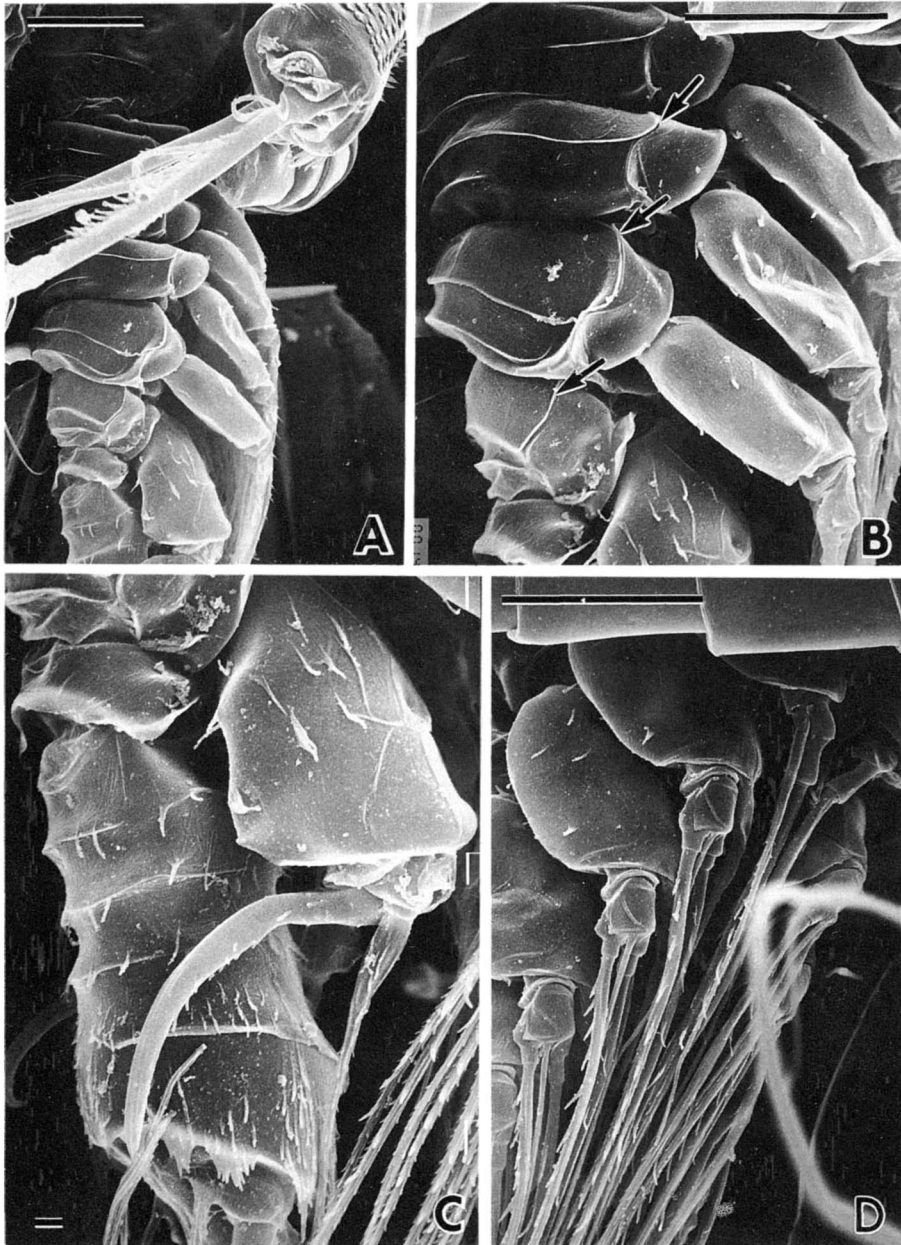


FIG. 7. *Itoitantulus misophricola* gen. et sp. nov. SEM micrographs of tantulus larva. A. Thoracic somites and urosome, lateral view; B. Thoracic somites, enlargement of A, tergopleural grooves indicated by arrows; C. Thoracopod 6 and urosome, enlargement of A, lateral view; D. Thoracopods 1 to 4. Scale bars = 10 μm (A, B, D); 1 μm (C).

Trunk sac located dorsally, posterior to 6th thoracic tergite. Head, rest of thorax and urosome remaining unchanged from preceding stage; 1st tergite beneath cephalic shield. Metamorphosing

male supplied with nutrients via tissue connection (umbilical cord) with larval head (Fig. 3-E). Male at early stage in material available; thoracopods 1-6 present, setose, details not visible; cepha-

lothorax with 4 pairs of aesthetascs (Fig. 3-C). Penis recurved at early stage of development (arrowed in Fig. 4-A). Caudal ramus armed with 3 short spiniform elements (Fig. 4-A).

Adult female (paratypes). Early stages of adult female showing scar formed by sloughing of larval trunk (arrowed in Fig. 4-C, D). Larval head unchanged from preceding stage (Fig. 4-B~D). Trunk sac contents undifferentiated at this early stage.

Etymology. The specific name "*misophricola*" is derived from the host misophrioid copepod, and the Latin *colere*, meaning to inhabit.

SEM observations of tantulus larvae of
Itoitantulus misophricola Huys, Ohtsuka
et Boxshall gen. et sp. nov.

Tantulus larvae of *Itoitantulus misophricola* were also examined with SEM (Figs. 5~7). The attachment sites of the examined tantulus larvae were on proximal segments of the antennules (Fig. 5-C) and the basis and rami of the antennae (Fig. 5-A, B) of the host misophrioid, *Misophriopsis okinawensis*. Isolated cephalic shields without thoracic somites and abdomen were often found remaining on the host (Fig. 5-B~D), probably due to damage during collection. The oral disc are shown in Figs. 5-C and 6-A, B. The oval oral disc is ca. 8 μ m in length and ca. 5 μ m in width. The cephalic shield has numerous integumental pores and sensilla and has complex epicuticular ornamentation. The integumental organs are basically distributed symmetrically except for two dorsomedial pores with a complex opening. The posterior margin of head (Fig. 5-D) has two pairs of fine sensilla (indicated by large arrows) and a pair of relatively large pores with collar (indicated by small arrows). The collar seems to function as an operculum of the pore, because some of pores are closed by the collars (see Figs. 5-D, 6-C), but this may be an artifact of the preparation process for SEM. Such integumental organs are hitherto unknown in any other tantulocaridan species [1-15]. The dorsal surface of head is entirely covered with fine mesh-like epicuticular ridges (Fig. 6-C, D), while the ventral surface has no epicuticular ridges such as on the dorsal surface but is smooth

(Fig. 5-D). A pair of longitudinal lamellar plates on the dorsomedial surface extends from near the oral disc to in front of the pores with a complex opening (Figs. 5-C, 6-C). These complicated epicuticular structures on the cephalic shield are also found in tantulus larvae of other genera, *Campyloxiphos*, *Coralliotantulus* and *Aphotocentor*, but not in *Microdajus* [3, 10, 12, 14, 15].

Thoracic somites lack mesh-like epicuticular ornamentation (Fig. 7-A, B), but each possesses a transverse lamellar ridge dorsally, and a pair of pleurae laterally separated by a deep tergopleural groove (Fig. 7-B, indicated by an arrow). Such deep tergopleural grooves on thoracic somites are also found in *Doryphallophora harrisoni* (Boxshall and Lincoln, 1987) [8].

The urosome is depicted in Fig. 7-C. The joint is between the seventh thoracic and first abdominal somites. The seventh thoracic somite is not ornamented. The abdomen is partly covered with small epicuticular prominences as in thoracopod 6. The caudal ramus is ornamented with serrated processes on the posterior end.

Thoracopods 1 to 4 and thoracopod 6 are shown in Fig. 7-D and -C, respectively. The outermost setae on apical exopod segments of thoracopods 1 to 4 are clearly found to be serrate. The curved, outer spiniform seta on thoracopod 6 bears minute spinules proximally and medially, and the lateral seta is also serrate.

DISCUSSION

The new tantulocaridan definitely belongs to the family Deoterthridae redefined by Huys [15], on the basis of 2-segmented urosome in the tantulus larvae, the absence of a rostrum from the tantulus, the segmentation of the rami of thoracopods, and the position of the expanded trunk sac in the male behind the sixth thoracic tergite. The Deoterthridae currently comprises six genera, *Deoterthron* Bradford et Hewitt, 1980, *Boreotantulus* Huys et Boxshall, 1988, *Dicrotrichura* Huys, 1989, *Aphotocentor* Huys, 1990, *Campyloxiphos* Huys, 1990 and *Coralliotantulus* Huys, 1990 [3, 15]. The new genus can be distinguished from all of these by the absence of a lobate endite from thoracopod 1. Another distinctive feature is the presence of the

dorsally-directed, recurved spine on the apex of the sixth thoracopod in the tantulus larva. This is not found in any other tantulocaridans although the form of the sixth leg of *Dicrotrichura* is similar. Within the Deoterthridae the affinities of *Itoitantulus* clearly lie with *Dicrotrichura*, with which it shares the modified caudal setae, an unarmed endopod on thoracopod 1 and a recurved medial seta on the sixth thoracopod (see [13]).

Itoitantulus misophricola is the first occurrence of the Tantulocarida in the North Pacific Ocean, although six species have hitherto been recorded from the shallow- to deep-seas around Tasmania, New Zealand and Peru [3]. As already shown by Huys [3], tantulocaridans are widely distributed from high latitudes to subtropical regions in both northern and southern hemispheres. The discovery of *Coralliotantulus coomansi* Huys, 1990 from the Great Barrier Reef [14] might have suggested a new locality of tantulocaridans in the subtropical regions in Japanese waters. Tantulocaridans are usually found parasitic on shallow- and deep-water epibenthic crustaceans but rarely on hyperbenthic or pelagic crustaceans except for the new tantulocaridans. This may suggest the epibenthic origin of ancestral tantulocaridans.

This is the first record of tantulocaridans parasitic on misophrioid copepods. The Deoterthridae currently accommodates seven species, four of which parasitized harpacticoid copepods, one parasitized ostracods and the rest were found free in sediment before attachment to hosts (see [3]). The present new tantulocaridan infested a variety of body parts of the host misophrioid copepods, namely, the antennules, antennae, mandibular palps, maxillipeds, and urosomes, but was most usually found attached to the antennae. Four deoterthrids parasitic on harpacticoids, namely, *Deoterthron lincolni* (Boxshall, 1988), *Boreotantulus kunzi* Huys et Boxshall, 1988, *Campyloxiphos dineti* Huys, 1990, and *Coralliotantulus coomansi* Huys, 1990 were attached to cephalosomes, urosomal somites, swimming legs and caudal setae of their hosts [9, 11, 14, 15]. *Deoterthron dentatum* Bradford et Hewitt, 1980 was found attached to a seta on the antennary exopod of ostracod [6, 15]. Within the Deoterthridae, only the present new tantulocaridan and *D. dentatum* have been found

infesting the cephalic appendages of their hosts.

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